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Periodic Relay Testing

PERIODIC RELAY TESTING

Periodic relay testing is, first and foremost, preventive maintenance. Thus, procedures and records should be designed with preventive maintenance as the guide. The tests themselves will reveal catastrophic failures which would have prevented the relay from performing when called upon to operate, while properly maintained records will reveal any trends which could lead to such failures.

The frequency of testing is subject to many variables, including type of relay, environment, and of course, history and experience. However, an annual or semi-annual schedule of maintenance is a good starting point. Table I lists some of the variables and their probable affect on maintenance scheduling.

TABLE I

VARIABLE	FACTORS LENGTHENING PERIOD BETWEEN TESTS	FACTORS SHORTENING PERIOD BETWEEN TESTS
Type of Relay	Simple (hinged armature, plunger)	Complex (distance, differential)
Environment	Clean, air conditioned	Contaminated atmosphere, dusty, extremes of temperature
Current Rating	Relay rated 5 amperes and operated at 5 amperes or below	Relays rated 5 amperes which are called upon to carry 7 or 8 amperes due to load requirements
Control Voltage	Nominal 125-vdc, battery operated within $\pm$5% of nominal	125-vdc, battery operated at 140 volts
Station Service Voltage	Relays rated 115 volts supplied with 115 volts $\pm$5%	Station service voltage 130 volts
Age	5 - 10 year old stations where previous history shows relatively few defects	Very new stations where relays having newly developed operating principles are used and for which maintenance schedules are yet to be developed. Stations 20 years or older where insulation aging, etc., are likely to be problems
History and Experience	Moderate or infrequent faults	Severe or frequent faults

The tests to be performed during routine maintenance are, of course, determined by the type of relay to be tested. However, the following tests should be included for all electromechanical relays. Also mentioned are some preventive measures which may be indicated by the results of such tests.

1. Inspection — Before the relay cover is removed, a visual check of the cover can reveal valuable information as well as prevent possible trouble. First, of course, excessive dust, dirt or metallic material deposited on the cover should be noted and removed. Removing such material will prevent it from entering the relay when the cover is removed. The presence of such deposits may call attention to the need for some form of air filtering at the station. "Fogging" of the cover glass should be noted and removed when the cover has been removed. Such fogging is, in most cases, a normal condition due to volatile materials being driven out of coils and insulating materials and, as such, merely requires its removal from the glass. However, if the fogging appears excessive, further investigation is indicated. Since most relays are designed to operate in ambient temperatures not exceeding 104 F, a check of the ambient temperature would be in order. The voltage and current supplied to the relay should be checked and compared with the nameplate and/or instruction book ratings. Should evidence of overheating be found, the insulation should be checked for embrittlement and, where necessary, replaced.

The removal of the connection plug in drawout relays may reveal evidence of severe fault currents or contaminated atmospheres, either of which may indicate the advisability of a change in the maintenance schedule. Similarly, the condition of the contacts can be equally revealing.

MECHANICAL ADJUSTMENTS AND INSPECTION

All connections should be tight. If several connections are found loose, excessive vibration may be indicated and should be corrected.

All gaps should be free of foreign material, and should excessive foreign material be found, inspection of the gasket is in order.

Moving gaps* should be measured and the values compared with previous measurements. Should there be a large variation in these measurements, exces-

*Contact gaps, armature gaps, etc.

sive wear may be indicated, in which case the worn parts should be replaced. It may also be found that an adjusting screw has worked loose and must be re-tightened. This information should be noted on the'test record.

All contacts** should be burnished and measured for alignment and wipe.

Since checking the bearings or pivots usually involves dismantling the relay, it is recommended that such a test be made only when:

1. The relay appears to be extremely dirty, or
2. Subsequent electrical tests indicate undue friction.

ELECTRICAL TESTS AND ADJUSTMENTS

1. Contact function — Manually close (or open) contacts and observe that they perform their required function, i.e. trip, reclose, block, etc.
2. Pickup — Gradually apply current or voltage to see that pickup is within limits. Since preventive maintenance is the guide post, gradually applied current or voltage will yield data which can be compared with previous or future data and not be clouded by such effects as transient overreach, etc.
3. Dropout or reset _ Reduce the current until the relay drops out or fully resets. This test will indicate excess friction. Should the relay be sluggish in resetting or fail to reset completely, then the jewel bearing and pivot should be examined. A 4X eye loupe is adequate for examining the pivot, and the jewel bearing can be examined with the aid of a needle which will reveal any cracks in the jewel. Should dirt be the problem, the jewel can be cleaned with an orange stick while the pivot can be wiped clean with a soft, lint free cloth. No lubricant should be used on either the jewel or pivot.

RECOMMENDED ROUTINE RELAY TESTS BY TYPE OF RELAY

1. Auxiliary Relays — Into this category fall such relays as HFA, HGA, HMA and perhaps PJV, PJC, and HNC relays. In addition to the tests previously described, those relays employing devices for time delay (for example, capacitors) should have an operating time test performed (either pickup or dropout, whichever is applicable).

**Except those contacts not recommended for maintenance.

2. Time – Overcurrent and Overvoltage Relays — Into this category fall such relays as IAC, IAV, etc. All the previously described tests should be performed where applicable.

Although this paper is primarily intended as a guide for routine relay testing, some consideration must be given to relay operating principles.

Consider, for example, the inverse (IAC51) time overcurrent relay. This relay has three torque-producing elements: the control spring which restrains the unit from operating and is the fine adjustment for pickup current; the drag magnet which retards the unit's operating time; the "U" or electromagnet which produces operating torque and is the coarse adjustment for pickup.

The shape of the time-current curve is essentially a function of the electromagnet iron circuit. As the current through the coil is increased, the flux increases, thereby increasing the torque and thus decreasing the operating time. However, at some current level above pickup, the iron begins to saturate, resulting in less flux (torque) being produced for a corresponding increase in current. Thus, the time current curve begins to "flatten out," i.e. approach some fixed time regardless of current level.

This saturation has two effects. First, the iron reluctance increases and flux is "spilled out" of the iron. The relay case normally acts as a shunt for this flux and the flux is passed through the case and not the relay disk. If the relay is tested in its case, the published curves will be duplicated, as well as "in service" conditions being duplicated. If, however, the relay is tested out of its case, the published curves may not be duplicated, nor will service conditions be accurately duplicated. Equally important from the preventive maintenance point of view, testing of the relay out of the case can yield results which will not check previous or future results. The reason for the discrepancy will not be a change in the relay characteristic but a change in the test conditions, for example, the relay's proximity to a steel cabinet. Thus, the true purpose of preventative maintenance may be lost.

The second effect of saturation is to produce non-sinusoidal currents. In service, the system impedance determines the relay current. Since the system impedance is limited by air-core reactances (the leakage reactance of generators and transformers), the relay is supplied with sinusoidal current. If we test the relay by allowing the relay to limit the current (low-voltage testing), we are allowing non-sinusoidal current to determine the relay characteristics.

Therefore we are not duplicating service conditions and again, we allow test conditions (voltage level and series resistance-reactance combinations) to determine relay characteristics, thereby losing the purpose of the tests.

The first electrical test made on the relay should be a pickup test. Pick-up is defined as that value of current or voltage which will just close the relay contacts from the 0.5 time-dial position. Allowing for meter differences, interpretation of readings, etc., this value should be within $\pm 5\%$ of previous data.

Generally, one or two points on the time-current curve are sufficient for maintenance purposes. Reset the relay to the original time-dial setting and two points that could be checked and 3 and 5 times pickup. Of course, other points could be used, but the important thing is to always use the same point(s).

The instantaneous unit should be checked for pickup using gradually applied current for reasons previously discussed. Wherever possible, current should be applied only to the instantaneous unit (to avoid over-heating the time unit).

The target seal-in unit should also be tested using gradually applied current. The main unit contacts must be blocked closed for this test.

DIRECTIONAL OVERCURRENT RELAYS

In addition to the tests previously described for the overcurrent relay, the directional unit should be tested for minimum pickup, angle of maximum torque, contact gap, and clutch pressure. Further, a test should be made to check that the overcurrent unit operates only when the directional unit contacts are closed.

The simplest pickup test for a directional unit is an in-phase test- i.e. current and voltage in phase. This test will eliminate the need for a three-phase supply, phase shifter, and phase-angle meter. However, it must be kept in mind that such a test is usually far from the angle of maximum torque (usually 60^{o} lag for ground relays) and thus, small changes in components can yield large variations in in-phase pickup. As long as this fact is recognized and the pickup value is within limits, an angle of maximum torque check would not be necessary.

Clutch pressure must always be measured in the same manner. For example, some instruction books express clutch settings in both grams and current/voltage levels.

Either test is valid, but to have comparative data, the same method, either grams or electrical quantities should be employed each time.

DISTANCE RELAYS

The previously described tests: pickup, angle of maximum torque, contact gap, and clutch pressure should be made.

Portable pre-calibrated reactance-resistance test boxes are available for many of these tests. The use of such equipment, properly applied, will yield results which will exceed in accuracy those obtained with conventional phase-angle meters, ammeters, voltmeters, etc.

DIFFERENTIAL RELAYS

A test of minimum pickup should be performed. The differential characteristic (slope) should be checked and where applicable the harmonic restraint should be tested.

Generally, differential relays are extremely sensitive devices and require some special consideration. For example, those relays employing ultra-sensitive polarized units as sensing devices are slightly affected by previous history such as heavy internal or external fault currents. To eliminate previous history and truly perform a maintenance test, it is the usual practice to disregard the first pickup reading and use the second reading for comparison with previous and future data. By "disregard" it is not meant to imply that the initial reading be forgotten; rather it is meant that this reading not be used for comparison purposes.

SUMMARY

There are many other types of relays not covered by this paper which require such specialized tests and test equipment that only instruction books and operating experience can determine the proper routine maintenance schedules.

Automatic synchronizing relays, speed matching relays, reclosing relays, etc. might be tested on routine maintenance by actual or simulated operation.

Timing of high-speed relays such as hinged-armature instantaneous units, cup-type units, and differential relays has been purposely omitted from routine maintenance tests for the following reasons:

1. Provided all other necessary tests have been made, a timing test will not reveal any additional necessary maintenance information.

2. Such tests require special initiation devices not generally available — For example a "wave switch" might be required. The "wave switch" referred to here is a switch which will apply voltage or current at some predetermined point on the sine wave of current or voltage.

3. Unless electronic timers, bounce free switches, etc. are used, the errors introduced by the timing equipment will by far exceed any difference in the relay operating time.

The most important "test equipment" is pride, for it is through "pride in workmanship" that any preventive maintenance program achieves its goal of maximum reliability at minimum cost.

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